SILVICULTURE

A Guide to Aerial Cone Collection Equipment and Techniques in British Columbia

Province of
British Columbia
Ministry
of Forests

A Guide to Aerial Cone Collection Equipment and Techniques in British Columbia

by

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Foreword

The collection of cones via aerial methods can be an effective means of acquiring seed needed to meet basic silviculture commitments. Over the last decade in fact, as the technology has improved and the benefits of aerial collection became more widely appreciated, the use of aerial methods has become increasingly commonplace in B.C.

In recent years the equipment options to conduct aerial collections have expanded and evolved considerably. The need for a comprehensive Guide to facilitate the use and selection of aerial cone collection equipment was thus identified by Ministry of Forests staff in the Prince Rupert Region. The Silviculture Branch was asked to initiate this project and has overseen its production.

Many individuals have contributed to this finished product. Equipment suppliers and users freely offered a great deal of information and photos and additionally provided in-depth technical reviews of the initial draft. The author, Bill Camenzind has, under contract, done a thorough job. Cam Bartram, of our Nursery and Seed Extension Section, played a key role in administering the contracts leading to publication and coordinating the review process. I wish to commend everyone involved for their efforts.

Peter Ackhurst, R.P.F.
Director
Silviculture Branch

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Many persons reviewed the manuscript and offered their suggestions. Cam Bartram, Ed McDonald, and Dave Wallinger deserve special recognition for providing a great deal of valuable information and thorough critical reviews. Leslie McAuley helped compile the appendices listing suppliers of aerial cone collection equipment and service.

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Bill Camenzind,
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Disclaimer

This guide does not purport to endorse aerial collection methods over any others. The mention of names or products does not constitute endorsement by the Ministry of Forests, R.J.A. Forestry Ltd., or the author.

A general overview of implementing an aerial collection is provided only. This guide is not intended as an operations manual to be relied upon in specific operations or specific situations. Users of this guide are advised that they do so at their own risk. Neither the Province of British Columbia, the author, nor any person who assisted in the preparation of this guide accepts responsibility or liability for damage or injury to persons or property in any way resulting from aerial cone collection as discussed in this guide.

Where this guide refers to particular helicopter models, or to manufacturers' recommendations regarding maintenance, reference should always be made to the manufacturer or the aerial cone collection contractor as to the suitability of a particular helicopter for a particular job and as to whether or not there are more recent manufacturers' guidelines regarding maintenance.

Similarly, although this guide mentions weather factors, operating conditions and general procedures, decisions regarding weather, operating conditions or procedures are the responsibility of the pilot or of the person in charge of a particular operation.

Users of this guide should familiarize themselves with the WCB regulations, Forest Fire Prevention regulations and Transport Canada regulations. Other Provincial or Federal statutes or regulations may apply to specific situations.

Aerial cone collection may involve risk to people and machinery. This guide is not intended to deal comprehensively with safety issues. Mention of specific safety concerns or regulations in this guide should not be taken to mean that there are no other safety concerns or regulations.

Table of Contents

Foreword iii

Acknowledgements iv

Disclaimer v

Introduction 1

Aerial Versus Ground Cone Collections 3

Aerial Cone Collection Methods 5

Decision Aid Table – Making the Right Decision 9

Aerial Cone Collection Systems 10
- Aerial Rakes 10
  - Chilson Rake 10
  - Fandrich Rake 11
  - Bicone Harvester 13
- Clippers and Saws 15
- Topper: Fandrich Tree Shear 17

Safety 19

Planning and Implementing an Aerial Cone Collection 20

Contact Persons 22

References 24

Appendix 1 – Suppliers of Aerial Cone Collection Equipment 27

Appendix 2 – Experienced Suppliers of an Aerial Cone Collection Service – Helicopter Companies 28

Appendix 3 – Experienced Suppliers of an Aerial Cone Collection Service – Consultants 30

Introduction

In the ten-year period from 1979 to 1988, a total of 64 428 hectolitres (1 hl = 100 litres = 2.83 U.S. Bushels) of cones were collected in British Columbia and registered with the Ministry of Forests. Figures 1 and 2, and Table 1 illustrate the volumes collected by year, Forest Region, and species respectively.

Aerial cone collection using helicopters can be a very efficient way of collecting cones. It can, however, be very expensive and less practical than ground methods (e.g., felling, climbing) if all factors are not taken into consideration.

This guide will assist the cone collection planner in choosing the most suitable collection method. The guide also presents information on the operation and relative advantages and limitations of the three main aerial collection methods: raking; clipping/sawing; and topping. A Decision Aid Table is also given which integrates, and adds to, the materials presented (page 9). Specifications on individual cone collection systems and equipment are provided. These specifications are current to January, 1990 and are subject to change. A section on planning and implementing an aerial cone collection project is included. Suppliers of aerial collection and equipment and services are also listed in the two Appendices.

Information and data for this guide were collected by reviewing the literature and consulting with users and manufacturers of cone collection equipment. The guide is meant to compliment *A Guide to Collecting Cones of B.C. Conifers* (Eremko, et al. 1989) which contains additional information pertinent to cone collections:

- collection planning procedures (cone collection requirements, crop forecasting, crop monitoring, pre-collection organization)
- proper cone collection and handling practises
- administrative requirements
- WCB regulations

Chapter 3 of the Ministry of Forests Silviculture Manual contains further information. VHS format video tapes describing cone collection procedures are also available from Forest Service Regional Offices.

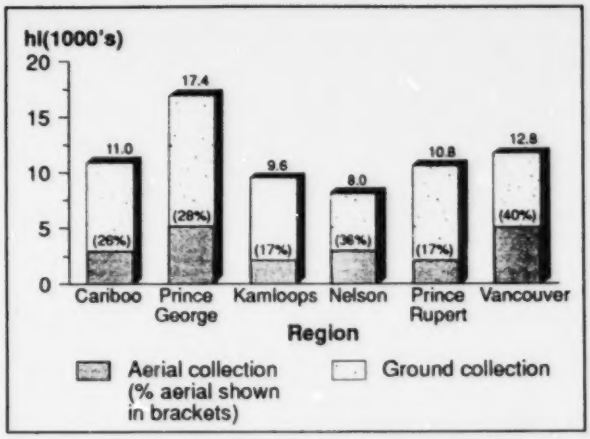

Figure 2. Volume of cones collected by Forest Region and by method from 1979 to 1988 inclusive.

Ministry of Forests' users are advised that the following policy items affect Ministry aerial cone collections:

- all aircraft hire must be performed in close liaison with Region Protection Air Operations,
- no Ministry personnel shall be on board a helicopter that is slinging a load,
- no Ministry personnel shall be on board a helicopter while that machine is actively collecting cones – no riders,
- no Ministry personnel may function as an aircrew collection operator – they cannot operate clippers or saws,
- Ministry personnel may, if they are trained and certified, carry out aerial branch sampling – refer to *Aerial Branch Sampling Training Manual.*

It is suggested that Ministry users work in close liaison with their Regional Air Operations Coordinator and Reforestation Coordinator.

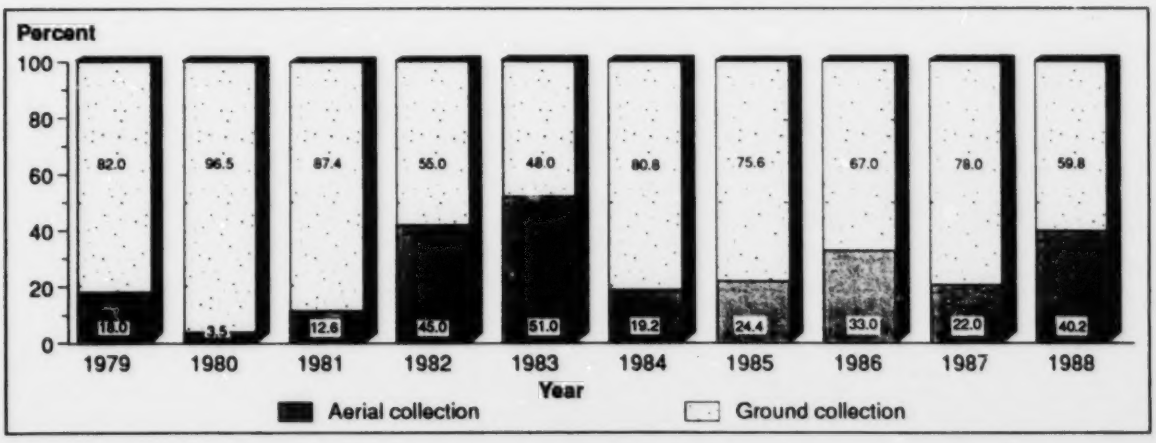

Figure 1. Cone collections for all Forest Regions from 1979 to 1988 inclusive – percent aerial versus ground collection.

Table 1. Volume of cones collected and percent aerial versus ground collection by species and year – 1979 to 1988.

Species	Year 1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Total hls by species
Douglas-fir	621[a]	214	30	1421	863	73	615	727	684	996	6244
(coast)	3/97[b]	0/100	0/100	45/55	0/100	0/100	0/100	0/100	0/100	0/100	
Douglas-fir	202	870	23	796	43	0	934	0	811	1526	5205
(interior)	0/100	0/100	0/100	19/81	0/100		39/61		52/48	56/44	
Subalpine	3	8	0	16	0	0	0	110	0	51	188
fir	0/100	0/100		0/100			0/100	100/0		98/2	
Amabalis	1917	73	116	882	380	0	222	498	74	629	4791
&Grand fir	87/13	97/3	100/0	86/14	98/2		100/0	96/4	75/25	100/0	
Spruce	8879	303	0	2835	5697	0	1225	438	257	1758	21392
(interior)	10/90	14/86		48/52	68/32		47/53	85/15	27/73	66/34	
Spruce	2105	1	0	2	214	2	0	848	13	366	3551
(coast)	4/96	0/100	0/100	100/0	39/61	0/100		67/33	0/100	79/21	
Lodgepole	764	1486	685	591	1086	2789	3232	2356	2837	3518	19344
pine	0/100	0/100	0/100	8/92	0/100	2/98	7/93	3/97	18/82	14/86	
Western	94	13	3	77	53	0	45	77	0	65	427
Redcedar	0/100	0/100	0/100	18/82	0/100		0	47/53	0/100	4/96	
Yellow-cedar	0	0	5	0	2	0	34	0	0	8	49
			0/100		83/17		21/79		0/100	42/58	
Hemlock	194	1	21	382	19	33	1	8	14	89	762
	5/95	0/100	0/100	55/45	48/52	0/100	0/100	0/100	0/100	67/33	
Others[c]	22	227	74	65	76	16	380	44	104	1471	2479
	Some aerial collections reported but minimal										
Total collections by year	**14801**	**3196**	**957**	**7067**	**8433**	**2913**	**6689**	**5106**	**4794**	**10477**	
										Grand total:	**64432**

[a] Total hectolitres (hls)
[b] % air/% ground
[c] White pine, Yellow pine,Western larch, and others

Aerial Versus Ground Cone Collections

The decision to collect cones with an aerial or ground-based system is often difficult, as each situation is unique and many variables are involved. This section will discuss some of the factors that influence the choice of collection method.

The three main aerial collection methods – raking, clipping/sawing, and topping – are discussed, as are felling and climbing; other cone collections techniques such as shooting or use of squirrel caches are not included as they are much less common.

Factors that Influence Choice

Physical Factors

Stand access

Access or distance from the road to the target stand is one of the most important factors to consider when choosing between aerial or ground-based collection. Helicopters can readily collect from areas which are out of reach of ground crews. Access may be physically obstructed by a river or ravine, or it may be a function of travel distance. In the latter case, there is a point where travel time by ground is not economical, and an aerial system should therefore be considered. Even with helicopters, however, lengthy cycle times and long ferry distances will, at some point, be too expensive.

In the case of remote stands, collection planners should consider one or more satellite staging areas. Here, cone laden branches can be stockpiled near the stand and transported to the bagging area at a later time, perhaps at day's end by cargo net. Such an operation requires careful planning, since the chance of leaving cones or ground crews stranded at the staging area owing to breakdowns or poor weather is a definite risk.

Aerial systems allow the cone-laden branches or tops to be trucked to town. The pickers can work in clean, comfortable surroundings with no time lost in travelling. A large semi-open building such as a machine shed or barn is ideal for picking. The roof will keep the rain and sun out, yet these buildings are usually open and encourage good air circulation. Air circulation can also be augmented with fans. Cones that might otherwise fall onto the ground and be lost, can be recovered. Care must be taken in transporting the tops/branches as the possibility of overheating is always present. A flat deck truck with wire mesh sides is preferable to a closed van. Self-dumping features, such as a tilting deck or box, are a great time saver.

Logging scheduled from target stand

Cones can be collected on the ground from an area being logged as long as the cones are ripe when the falling and picking take place. Also, if a stand is to be logged soon, prefelling of some or all of the crop trees with a view to collecting cones is a good alternative. Both of these approaches require planning and cooperation between silviculture and logging interests.

If logging is scheduled and the compromises discussed above cannot be made, an aerial collection may be warranted.

Terrain

Extremely rugged terrain or terrain that will impede both logging and ground-picking crews may be best worked by aerial systems.

Stand Factors

Scattered crop trees

While this situation is not optimal for either aerial or ground systems, it is particularly onerous if ground collections are to be made. Too much time is required for finding, felling or climbing, and collecting the cones from scattered crop trees. A helicopter can collect from a large area in a relatively short time. There is, however, a threshold after which air time spent searching for and traveling from one crop tree to another becomes too expensive.

Crop trees co-dominant or in lower canopy

Rakes and toppers can reach down into a stand canopy, but on-board clippers cannot. Climbing is possible, as is felling.

Many snags

The presence of snags above the live canopy usually presents an extremely hazardous situation for a helicopter. Ultimately, the pilot must choose if the stand is suitable for aerial picking. Raking or topping may work in stands that are inaccessible to clippers. Ground collection methods are viable in areas with snags, but fallers or other ground crew must exercise caution.

Crop trees reserved from felling

Numerous stands may be reserved from felling: leave strips; Park Reserves; seed production areas; and others. In such stands, aerial methods or climbing will enable collections to be carried out.

Tree Factors

Cone position in crown

The occurrence of many cones in the upper crown is important to the success of aerial collections. Aerial clipping or sawing is generally restricted to the top 2.5 m of the crown, unless multiple cuts can be made. Rakes normally can accommodate 3-4 m of crown, while the topper is limited by the diameter of the trunk (i.e., up to 15 cm).

Falling a tree allows picker access to the whole tree and is thus more suitable when the crop is distributed throughout the crown. A high proportion of cones, however, may be knocked off or trapped beneath when the tree falls. Climbing a tree will provide access to the lower and middle portions of the crown, but usually not to the very top.

Aerial Versus Ground Cone Collections

Immature crop trees
Crop trees considered immature by utilization standards may be exempt or unsuited to felling. In these instances, climbing is the preferred method as it causes the least damage to the tree. Aerial collections from immature trees are possible and are discussed below.

Minimizing damage to crop trees
Felling obviously damages the crop tree, while climbing will have minimal impact. All aerial cone collection systems damage a tree to some extent by either stripping off some or all of its upper branches, or by removing the top. The majority of aerial cone collections to date have been on mature trees where damage to the crown was of little consequence. Collections from immature crop trees may require that the leader be undamaged, leaving careful raking or branch clipping/sawing as the only aerial options. The risk of decay organisms entering a tree through aerial collection scarring is minimal, unless heartwood is exposed. Heartwood usually occurs in a tree where the trunk diameter reaches approximately 15 cm.

Other Factors

Weather
Most cone collections take place in late August through September, a time of year when seasonal weather patterns are changing. Conditions such as high winds, rain, and fog can compromise the safety of an aerial cone collection. While not optimal for ground collections, these conditions can at least be accommodated. Snow, either falling or accumulated on the tree tops, as may occur on late season high elevation collections or with winter lodgepole pine collections, can hide cones and further impede aerial collections. Wet snow or ice buildup on the tree tops can also add unwanted weight and reduce payloads.

Narrow collecting "window"
Aerial methods enable the collection of large quantities of cones in a short time. Ground methods can however, if properly planned, accomplish the same result. Aerial methods should not be relied upon as a replacement for inadequate planning.

Cone and seed quality
The goal of any collection is clean, ripe cones free of insects and disease. Any cone collection method can accomplish this, and thus no one method can be considered better or worse than any other.

The selection of high quality crop trees is an important factor to consider when collecting cones. Aerial observation can readily identify the tallest, straightest trees, whereas ground observation enables comparison of lower bole size and form characteristics. Both aerial and ground methods, however, enable the identification/rejection of poorest quality crop trees.

Costs
Cone collection costs are extremely variable and make up a relatively minor proportion of the overall reforestation cost. Supply and demand for seed may override cost considerations if the need for seed is high. Although aerial collection methods are often more expensive than other methods, they may be more suitable due to the factors outlined above.

Aerial Cone Collection Methods

There are three principal methods of aerial cone collection currently approved in British Columbia: clipping/sawing, raking and topping. This section will briefly describe each method and comment on some of the factors that can affect their success.

Aerial Raking

Aerial raking utilizes a raking device slung beneath the helicopter (Figure 3). Rakes resemble an upright truncated cone surrounded by a framework screen. The rake is lowered over the target tree and then lifted up by the hovering helicopter. Blades at the apex of the rake's cone cut or break off cone-laden branches and they fall in the framework. Repeated lifts (cuts) on one tree are possible and often necessary to remove branches from all parts of the crown. When the basket is full, the helicopter returns to the unloading area and the branches are removed.

Figure 3. Aerial raking.

Aerial Clipping/Sawing

Aerial clipping is performed by an operator, seated in the right rear seat of a helicopter with its door removed. The operator severs the cone laden top and/or branches using a hand-held hydraulic clipper or an electric chain saw (Figure 4). Tops are stowed in the rear passenger compartment, or slung beneath the helicopter by choker. Once full, the helicopter returns to the unloading area where the tops are removed.

Aerial Topping

Aerial topping is the most recent development in aerial cone collection. The topper resembles a rake but harvests the entire top of the tree rather than just the branches (Figure 5). The topper is lowered over a target tree by the hovering helicopter. The top is then severed by means of a hydraulic shear mounted on the apex of the topper. The shear is powered by a gasoline engine which is mounted on the topper and activated by the pilot. Severed tops fall into the collecting basket surrounding the topper. Once the basket is full, the helicopter returns to the unloading area.

Figure 5. Aerial topping.

Figure 4. Aerial clipping/sawing.

Aerial Cone Collection Methods

Factors to Consider When Selecting an Aerial Method

Each of the three principal aerial cone collection methods listed has advantages and limitations (Table 3). Below are listed several factors that will directly or indirectly influence your choice of a particular method.

Species

Amabalis and Grand fir

- Cones situated near the top of the crown are ideally suited for aerial raking – can be very productive, note the consistently high percentage of aerial collection in Table 1.
- Limited experience with topping but results similar to raking expected.
- Very little aerial clipping/sawing to date, possibly due to the awkward and heavy tops. Older trees with flat, bushy tops may be difficult to harvest.

Subalpine fir

- Very few cones collected to date, demand expected to grow.
- Suitable for raking, topping and perhaps clipping and sawing due to spire-like top.

Douglas-fir (coastal)

- Cones are generally located in the top half of the crown and are suitable for raking or multiple topping and clipping.
- Many of the agencies contacted predicted a close to 100% reliance on seed orchard seed in the foreseeable future.

Douglas-fir (interior)

- Interior Douglas-fir has increasingly been harvested using aerial methods (Table 1).
- Suitable for all types of aerial collections.

Western redcedar

- Aerial raking has been carried out, and rakes which go far down the tree yield more cones per tree.
- Clipping/sawing and topping are also suitable.
- Cones located throughout the crown are somewhat more suited to felling.

Yellow-cedar

- Cones distributed throughout the crown, and the presence of both 1- and 2-year-old cones can make aerial collection from this species expensive.
- The species has been raked, although costs were very high – up to $3000/hl.

Western hemlock

- Cones occuring throughout the crown are somewhat more suited to felling, although raking, topping and clipping/sawing are possible.
- The species' narrow crown allows multiple rakes or cuts to be made.

Western white pine

- Cones located in the top quarter of the tree are suitable for raking.
- There have been some clipping collections, but no topping.

Lodgepole pine

- The serotinous nature of lodgepole pine allows picking to take place in the winter, often in combination with logging.
- Table 1 indicates an increase in the use of aerial methods.
- Most Pl stands are even-aged with relatively even canopies, precluding clipping in most cases. Rakes and toppers can be used.

Spruce (coastal and interior)

- The tendency for spruce to grow in mixed stands provides a broken canopy which is ideal for clipping.
- The presence of cone insects and rusts on a sporadic basis favours the clipping method as the operator can cull in the air.
- Rakes and toppers can also be used.
- Note the relatively high percentage of aerial collections of interior spruce in Table 1 for every crop year.

Other species

- Western larch and yellow (ponderosa) pine have been collected aerially.
- There was an attempt to collect black cottonwood whips using an aerial rake. The springy nature of the whips, however, prevented the rake (an old Chilson model) from succeeding. A topper or clipper may be more successful for collecting cottonwood material.

Stand Type and Terrain

Stand type is important, especially with regards to canopy structure. An open, broken canopy or one with crop trees in the dominant position is accessible to all aerial harvesting systems, and is probably best suited to clipping. A flat, even canopy or one with crop trees codominant or lower is probably inaccessible to clipping. Target trees within these stands are usually within the reach of rakes or toppers, as these systems can penetrate into a forest canopy to a limited extent.

Aerial Cone Collection Methods

Table 3. Advantages and limitations of aerial cone collection methods[a]

Aerial Raking	
Advantages	**Limitations**
• can penetrate many canopies • no operator required • simple technology/low maintenance • simple hook-up	• choice of tree left to pilot • stress on helicopter • more powerful helicopter required • generally requires ground crew to unload • low ferry speed if transported to site by air (deadheaded)
Aerial Clipping/Sawing	
Advantages	**Limitations**
• operator selects tree • harvests whole top (or just branches) • easy to transport • no ground crew required • spare parts quickly available	• requires 1 or more trained operators and skilled pilot working closely together • extensive temporary modifications to helicopter, especially rear seat • cannot penetrate canopy • relatively high maintenance • greater wind restrictions
Aerial Topping	
Advantages	**Limitations**
• can penetrate many canopies • no operator required • no helicopter lift required to perform cuts • helicopter readily available for other uses • easiest system for pilots to learn	• choice of tree left to pilot • ground crew required to unload • low ferry speed if transported to site by air (deadheaded) • potential high maintenance time/cost • potential fire hazard

[a] Refer to pages 10-18 for a detailed description of the systems mentioned here.

Wind and Weather

Wind is one of the most serious (albeit temporary) factors involved in aerial cone collections, especially clipping. Raking and topping are also affected by wind. Helicopters using a rake or topper can orient themselves to face into the wind, whereas this manoeuvre is often limited in clipping. The majority of helicopter companies who undertake aerial cone harvesting have a maximum wind velocity criterion in their operations manual.

Of equal importance is the direction and stability of the wind. A gusty wind which is ever changing direction is a serious threat to a hovering helicopter. Downdraft winds which may be encountered on a steep slope are also not conducive to safe and successful aerial cone collections. It is the pilot's responsibility to assess the wind situation and decide whether it is safe to fly.

Helicopter Availability and Type

Aerial cone collection is a relatively minor component in most helicopter companys' operations and their full range of machines may thus not always be available.

The three main methods have different helicopter requirements. Clipping utilizes Bell 206B Jet Rangers exclusively, whereas raking requires the more powerful Hughes 500D, Bell 206L or equivalent. Raking subjects the helicopter to more stresses than normal hovering and some helicopter companies may not use rakes for this reason. The topper can utilize a Bell 206B.

Availability of Expertise

Pilot experience is an important factor in any aerial cone collection. The Workers' Compensation Board of B.C. requires that pilots have a minimum number of hours flying time as pilot in command. Aerial cone collections require a degree of skill that cannot be gained from other work however. Amongst the various collection methods, aerial topping requires the least special skill from the pilot. This is followed closely by raking. Aerial clipping, however, requires a very skilled pilot and a skilled operator, and they must function as a team in order to be safe, productive, and efficient.

Transport and Ease of Setup

The transportation options for each piece of equipment are discussed beginning on page 10. Clipper and saw systems are the simplest to transport, as they can be readily carried in a vehicle or shipped by commercial carrier. Rakes and the topper should not be ferried long distances as they slow the helicopter down considerably.

Cone rakes are easy to install (simply clip them into the helicopter's sling hook). The Bicone harvester and the aerial topper require electrical hook up in addition to the sling hook. Clipping and sawing systems require that the rear passenger compartment be stripped and lined with a protective liner, as well

as installing the clipper power pack. Some clipper and saw systems require hardwiring to the helicopter whereas others do not.

Users normally need not concern themselves with the ease of set up as this is the responsibility of the helicopter company.

Ground Crew

A ground crew to unload a topper or rake represents a cost to the user. Ground crew work may be considered hazardous as they are in close proximity to the hovering helicopter and the suspended collecting tool, and are also working within the rotor wash during unloading. Systems that do not require a ground crew or at least minimize it (such as unloading directly into trucks) may have safety or cost advantages.

Fire Hazard

The aerial topper available in B.C. has a gasoline engine carried on its framework. During dry periods, there may be concern over the threat of the engine igniting a forest fire. Users must be aware of the Forest Fire Prevention Regulation and the local fire hazard.

Cone/Seed Quality

In target stands where there is scattered insect or disease occurrence, clipper and saw systems have an advantage over other aerial systems because the operator has an opportunity to examine the cones more closely before selecting or rejecting the tree.

Costs

No one aerial collection system can be considered more or less economical. The myriad of external factors and the normal fluctuations within species and crop years have an overriding influence. Historical costs support this and, therefore, cannot be relied upon for projecting costs or used as a basis for selecting a particular collection method.

Decision Aid Table – Making the Right Decision

The following table rates the suitability of cone collection methods based on individual factors. Each factor should be examined in turn, and their combined impact evaluated prior to making a decision.

Factor	Suitability Rating[a]			
	High	Medium	Low	Not suitable
Access				
Target stand adjacent, logging scheduled	felling		clipping/raking/ topping/climbing	
Target stand adjacent, logging not scheduled	climbing	clipping/raking/topping	felling	
Target stand not adjacent,				
but < 1 km (approx.)	climbing	clipping/raking/topping	felling	felling
1-3 km (approx.)	clipping/raking/topping	climbing	climbing	felling
> 3 km (approx.)		clipping/raking/topping		felling/climbing
Extremely rugged terrain	clipping/raking/topping		felling/climbing	
Stand Factors				
Scattered crop trees	clipping/raking/topping		felling/climbing	
Even canopy, or crop trees lower in canopy	raking/topping	climbing/felling		clipping
Snags above main canopy		climbing/felling/ raking/topping		clipping
Crop trees reserved from felling	climbing	clipping/raking/topping		felling
Tree Factors				
Cone location upper 2 m	raking/clipping/topping	felling		climbing
in crown upper 5 m	topping/raking	felling/clipping	climbing	
throughout	felling/climbing	raking/clipping/topping		
Crop trees immature	climbing	raking/clipping/topping	felling	felling
Sporadic insects in cones	climbing/clipping	raking/topping	felling	
Other Factors				
Narrow collection window	raking/clipping/topping	felling/climbing		
Inclement weather	felling/climbing	raking/clipping/topping		
Limited helicopter lift	clipping/topping	raking	raking	

[a] The suitability of the felling method is dependent on the feasibility of log salvage. When rating climbing it is assumed that climbers are available and that the species/tree form is suitable. Suitability of sawing is comparable to clipping.

Aerial Rakes: Chilson Rake

The Chilson Rake, or the Helicropper, was the first operational rake to be used in B.C. The developer, Charlie Chilson, is no longer involved in its production or promotion. A few rakes still exist, but are owned by other agencies.

Description

The Chilson rake has an all aluminum circular cone body with a replaceable metal cutting head (Figure 6). An expanded metal basket and framework surrounds the rake. The head has erect comb-like collecting tines which act to guide branches to the cutting edge at their base (Figure 7). Different heads with various tine sizes and spacings were, but are no longer, available. The rake is suspended beneath the helicopter by three cables, affixed to the side of the rake's cone.

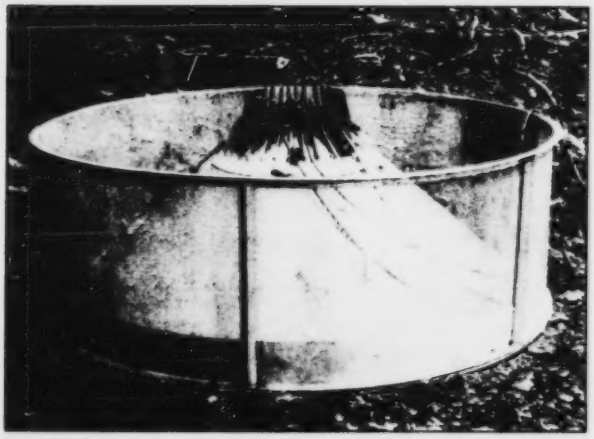

Figure 6

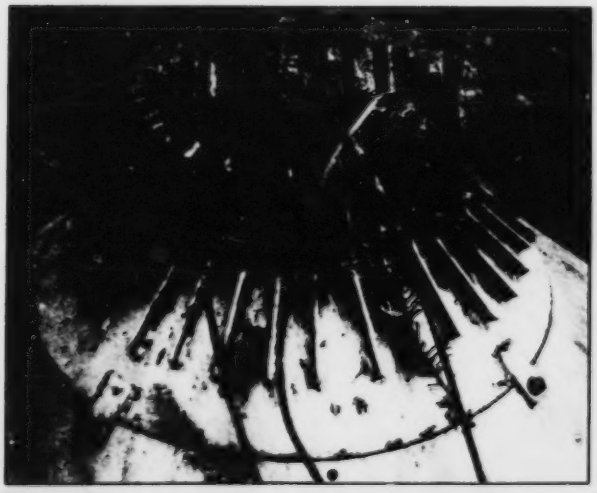

Figure 7

The Chilson rake is 2.2 m in diameter. The height of the basket is 0.8 m and the height of the cone to the base of the teeth is 0.9 m. The rake weighs approximately 182 kg.

Method of Operation

The rake is lowered over a tree and lifted up, whereupon branches are cut or broken off by the cutting edge and collected in the basket (Figure 8). Unloading of the rake is performed on older models by manually tilting the hinged basket upright once the rake is on the ground, and clearing it of branches (Figure 9). Later models had four legs fitted to the basket so that upon set down, the cone would be lowered free of the basket, facilitating branch removal. In this latter model, the helicopter could continue hovering, whereas the earlier hinged version required the helicopter to briefly land.

Maintenance and Upkeep

The body of the Chilson rake is extremely sturdy, and minimum maintenance is required other than inspecting the rigging and the basket. However, on earlier models tooth bending and breaking were common. The existing operational rakes have had extensive repair and reinforcing. Tooth inspection and periodic sharpening are recommended.

Suitable/Preferred Aircraft

Suitable: Turbo Hiller Models
Bell 206L/Hughes 500D

Preferred: As above

Helicopters having lift under 550 kg are not suitable.

Transportation

May be transported on a flat deck trailer or truck, or on a pickup with a frame over the box. The rake is difficult to load by hand due to its weight.

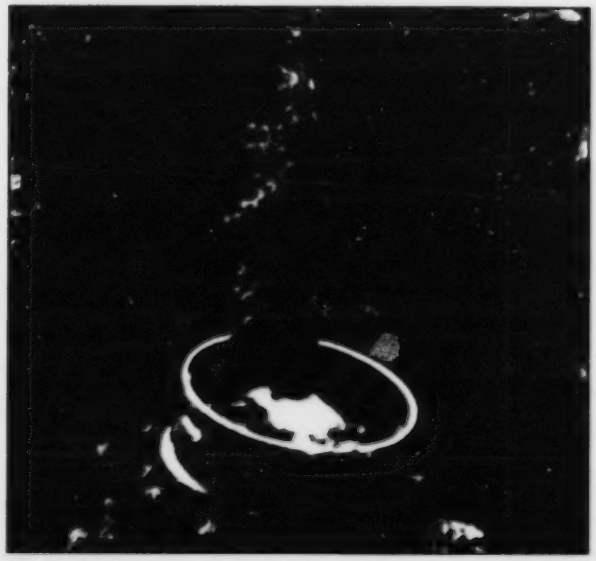

Figure 8

Figure 9

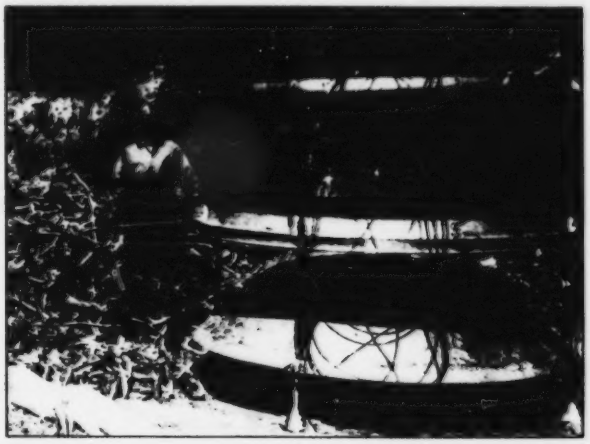

Figure 10

Supplier/Availability/Costs

The Chilson rake is no longer in production. Northern Mountain Helicopters of Prince George have two (older style) and the Ministry of Forests in Smithers has one older model. These rakes have limited potential for operational use at present.

The only Chilson rakes which are fully available for operational use are the two owned and operated by D.K. Helicropper International of Abbotsford. These two rakes are the four-legged model which are easier to unload (Figure 10). The collecting teeth have been extensively modified.

Advantages/Limitations

Advantages	Limitations
• very sturdy, robust design	• heavy (payload reduced)
• easy to operate	• may jam on tree
• no complicated components	• tines easily bent or broken unless reinforced
• automatic basket lifter on later models	• tines often jam with branches
• relatively simple unloading, even on earlier models	• no replacements available
	• limited availability

Fandrich Rake

Description

The Fandrich Cone Rake consists of a fiberglass cone-shaped body with a replaceable metal cutting head (Figure 11). The cone body is surrounded by a circular wire mesh and aluminum frame basket. The rake is carried below a helicopter by three wire cables which attach to the helicopter's cargo hook. The rake is 2.4 m in diameter, 1.2 m high and weighs approximately 136 kg.

Method of Operation

The cutting head is designed to position the tree top into one of ten cutting slots (Figure 12). Then, the upward movement of the helicopter and rake allows the serrated cutting teeth to shear or tear off cone laden branches. This operation may then be repeated on other sides of the tree. Some pilots find they can remove an entire top if need be.

Unloading the Fandrich Rake is accomplished by raising the basket free of the cone body, using helicopter lift. Branches and cones are thus able to fall freely from the rake, although often some hand clearing is required (Figure 13). In addition to the main support cables permanently attached to the

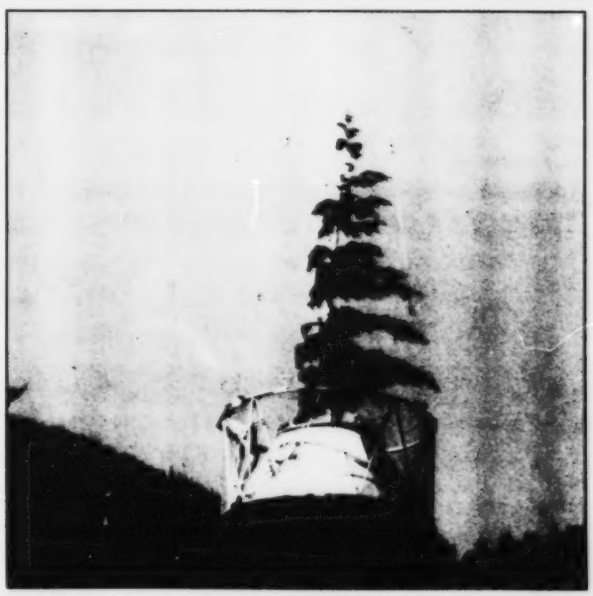

Figure 11

bottom of the cone body, three smaller secondary cables are affixed to the top of the basket and at a point 1.5 m up the main cables. In the collecting mode the secondary cables are slack and the basket rests on the cone body, held by its weight. For unloading, a full rake is placed on the ground and slack introduced to the main cables by the hovering helicopter. A spring powered tensioning device mounted on the outside of the basket is activated accumulating all the slack in the secondary cables, while leaving the main cables slack. The rising helicopter then lifts the basket free of the cone body before the main cables tighten and lift the cone itself. Lowering the now empty rake to the ground will release the secondary cables, placing the rake back into the collecting mode.

The spring tensioning device may be set to trigger either automatically when the helicopter touches down or manually by a ground crew member. The rakes also have provision for complete manual unloading.

Maintenance and Upkeep

The rake body, being made of fiberglass, is relatively maintenance free although minor spots may need repair. Major cracks or weak spots which may occur are generally addressed by the supplier. The wire mesh basket should be checked for holes or tears and repaired if needed. The main support cables should be checked daily (or more) for wear, ensuring fasteners and swivels are tight and operable. The unloading cable tensioning mechanism should be checked to spot any frayed cables or damage which could affect smooth operation of the rake. Little upkeep is required on the cutting teeth. Broken teeth are rare, and field replacement is difficult since the blades are welded on. Sharpening the tool-steel teeth is occasionally required – a hand grinder is more efficient than filing.

Suitable/Preferred Aircraft

Suitable: Bell 206, 206L, Hughes 500D, Turbo Hiller

Recommended: Bell 206L, Hughes 500D or Turbo Hiller

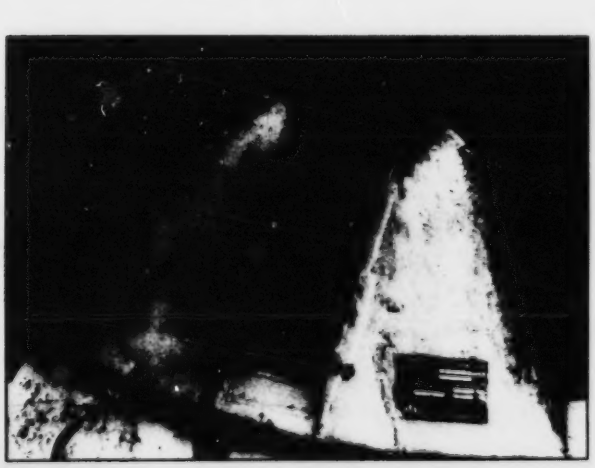

Figure 12

Figure 13

The manufacturer/supplier specifically advises against using a helicopter with a lift in excess of 682 kg. This is meant to ensure that the main support cables do not separate from the rake and endanger the helicopter's main rotor disc.

Transportation

The Fandrich Cone Rake may be transported on a flat deck trailer or truck, or on a pickup with a frame over the box. It is light enough for manual loading. Transport costs are normally the responsibility of the user.

Advantages/Limitations

Advantages	Limitations
• simple raking technology and time proven design	• requires helicopter lift
• good past performance	• >1 pass required to rake all branches
• relatively light weight	• transport costs
• automatic unloading with manual backup	• rental surcharge from manufacturer is fixed and thus there are no economies of scale

Supplier/Availability/Costs

The Fandrich Cone Rake is manufactured and supplied by Fandrich Cone Harvesters Ltd. (see Appendix 1). The rakes are not sold to other parties but rather rented to users (generally helicopter companies) on a seasonal or job basis. There is a flat rental fee of $320.00 plus a surcharge of $32.00 per

hectolitre. The renter/user is responsible for transport of the rake, as well as any extraordinary repair over and above regular wear and tear. Fandrich Cone Harvesters Ltd. also requires that the renter carry insurance for the rake. Replacement cost of the rake is placed at $8000.00.

There are twelve rakes in use but only seven of these rakes have the fully automatic unloading feature. The Fandrich Rake is patented in Canada and the U.S.

Bicone Harvester

Description and Operation

The Bicone Harvester, or the Robe Rake, consists of a flared, hexagonal aluminum-topped cone with six V-shaped cutting slots. A two-piece wire mesh and aluminum basket surrounds the cone. Both the cone and the basket are fitted to a large aluminum yoke which is attached to the helicopter via a single cable (Figure 14). The replaceable knife blades are made from stainless steel (Figure 15).

In use, the pilot lowers the rake over the tree, and then lifts it up. The knife blades are designed to slice branches off at an angle from two sides (Figure 16), rather than shearing or breaking them off as in other rakes. The large size of the rake and the cutting head design allow it to be slipped far down the tree crown. This enables more branches to be collected from each tree.

The Bicone has a fully automatic dumping process which is activated by the pilot. The rake's cone and one half of the basket pivot on the attaching yoke, and swivels approximately 90°. This allows branch material to fall freely to the ground or into a transport vehicle (Figure 17). The opening and closing of the rake are accomplished with an electrically driven hydraulic pump which is housed in the top of the yoke and powered by the helicopter's 24 V DC electrical system. The motor draws 30 amperes and runs only during opening and closing. Cycle time for opening/closing is approximately fifteen seconds.

The Bicone Rake may be stored or transported in the open position reducing the overall height to approximately 2.5 m (Figure 18). Deployment of the rake from this position to the upright (picking) position requires helicopter lift as well as electrical

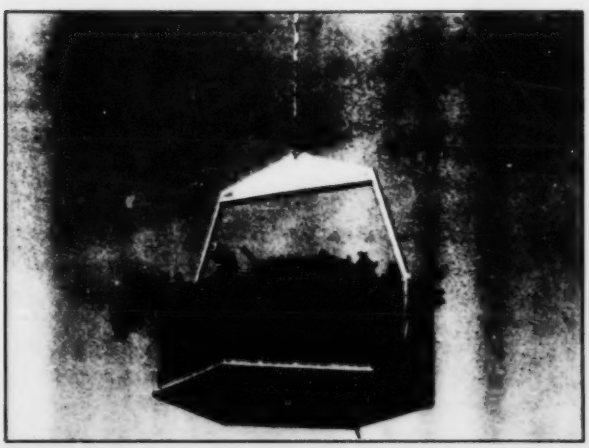

Figure 14

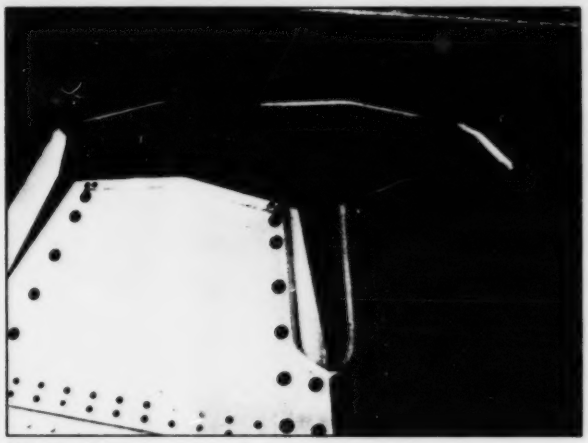

Figure 15

Figure 16

power. This is a safety feature designed to prevent the rake from closing (ie. orienting the yoke vertically) when beneath the rotor of the helicopter. Once in the air, deployment from open to closed is achieved by electro-hydraulic power and gravity.

The Bicone is approximately 3.0 m wide and 3.0 m high. The cone and basket are 1.25 m high. Total weight of the unit is 250 kg.

Maintenance and Upkeep

The rake is sturdy and well built. The moving components of the rake require regular inspection and lubrication. The hydraulic system's fittings and fluid levels should be checked periodically. The rigging system is the simplest of any aerial raking system.

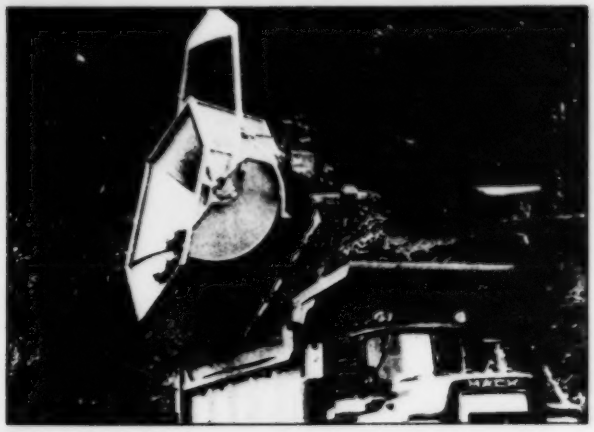

Figure 17

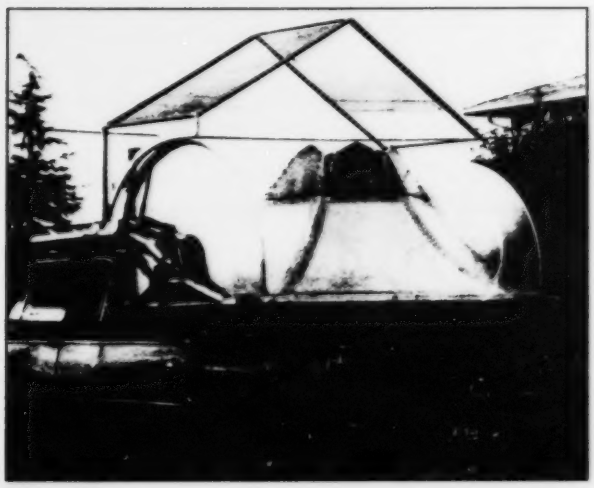

Figure 18

Suitable/Recommended Aircraft

Suitable: 204B, 205, (206L requires more study)
Recommended: Bell 204B

The large size and weight of the Bicone Rake require a helicopter with a lift in excess of 700 kg to work at maximum capacity. A Bell 204B has been used on most of the rake's operations. Trials with a Bell 206L (Long Ranger) were successful, but loads were smaller.

Transportation

The Bicone Rake may be carried on a flatbed truck or trailer as well as on a pickup. A framework must be built on the pickup box so the rake will straddle it. An over-width permit (>2.6 m) is required for highway travel. Detachable wheels are available which facilitates moving the rake on the ground but are suitable for hard surfaces (eg. a runway) only. The heavy weight of the unit (250 kg) makes manual loading difficult if not impossible.

Advantages/Limitations

Advantages	Limitations
• self-dumping	• requires large helicopter, potentially more expensive (requires more planning)
• no ground crew required (cost savings and safer)	• difficult to load and transport
• large capacity (maximizes productivity and minimizes ferry time)	• relatively complex dumping mechanism (potential down time)
• fast in-flight ferry time	• orientation of dump often difficult to control due to rake twisting upon opening
• cuts branches easily (less stress on machine and pilot)	• only one in existence, therefore no backup or spares
• very sturdy construction	• some users reported blade jamming in earlier model

Manufacturer/Availability/Costs

The Bicone Rake is manufactured by ROBE Innovations Inc. of Victoria, B.C. A 12-minute video tape of this unit in operation is available from the manufacturer.

Comments

The Robe Bicone Harvester holds promise due to its knife design and self-dumping feature. Its major drawback is the fact that a medium helicopter is required to work it to its full potential. Such a helicopter, the Bell 204B for example, costs approximately 1.75 times as much to operate as a Bell 206L and over twice as much as a Hughes 500D. This fact is not an issue if the production of the large machine offsets the cost differential. Early trials of the Bicone Harvester would seem to indicate that this occurs but cannot be guaranteed. More study of the Bicone Harvester under varying conditions is required before recommendations can be made. A smaller, lighter rake incorporating the Bicone feature has been discussed, but has not been developed.

Clippers and Saws

There are three clipping and two chain saw systems currently available. The clippers share the same basic technology and method of operation, and will be discussed together. The saw systems will likewise be combined.

Clipper Systems

The helicopter is prepared for clipping by removing both right side doors. A counterweight of approximately 40 kg is placed in the left front passengers' compartment for ballast. The rear passenger compartment is lined with a polypropylene liner or tarp to protect it from debris and tree pitch. The clipper operator sits on the right rear seat with their feet on the skid. In addition to the seat belt, a safety harness is worn at a all times. The operator and pilot have live two-way communication via their headsets. When a crop tree is selected, the helicopter hovers beside it, often touching it with the skid. The operator grasps the top with the left hand while operating the clipper with the right (Figure 4, page 6). The severed top (or branch) is pulled into the passenger compartment behind the operator. Once full of tops, the helicopter returns to the unloading zone where the tops are removed by the operator.

All clipper systems consist of two main components, a hand held hydraulic clipper and a separate power pack that contains an electrically driven hydraulic pump (Figure 19). The clipper head is a modified horticultural pruning shear with a hook shaped fixed blade and a curved pivoting blade (Figures 20/21). An electrical switch mounted on the clipper handle activates a hydraulic piston to open or close the blades, which cut in a scissors action. The blades will cut a 6.5 cm stem in less than 2 seconds.

Figure 19

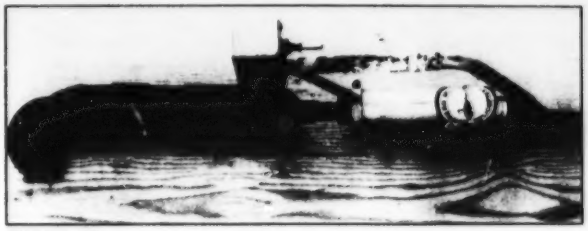

Figure 20

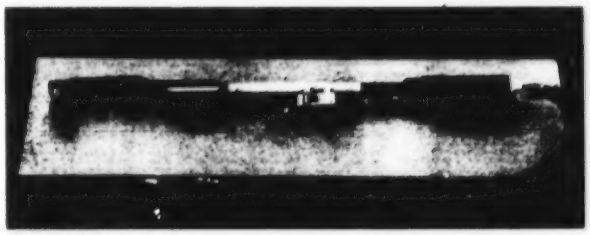

Figure 21

The clipper systems manufactured and used by Canadian and Northern Mountain Helicopters utilize hydraulic pump pressure to both open and close the blades, whereas the Frontier Helicopter system uses a hydraulic accumulator to close the blades and pump pressure to open them. As a safety feature, all clippers are equipped with an electrical cut off switch that disarms the handle switch. They also have break-away couplings on the hydraulic hoses.

Saw Systems

Electric chain saws are also used to sever the cone laden top or branches in a similar fashion to clipping. Highland Helicopters utilizes a 110V AC saw fitted with a protective guard on the bar (Figure 22). This guard acts to protect the operator and guide the saw through the stem. The cutting slot in the guard has a 10 cm capacity and the saw will cut through a top in less than two seconds. Power for the saw originates in a 24V DC to 110V AC converter carried aboard the helicopter (Figure 23). The operations of approaching, cutting, stowing, and unloading the tops are the same as outlined in clipping.

The other chain saw system utilizes similar equipment, but different storage techniques. A 12V DC chainsaw is used, powered by a battery carried aboard the helicopter. Approaching and cutting

Figure 22

operations are the same as above except that the original system has the operator standing or kneeling on a platform mounted on the skids, not sitting on the seat. The severed tops are slung beneath the helicopter by polyproplene rope chokers (Figure 24). When all the chokers are used up, the helicopter returns to the unloading area, releases the load of tops and picks up a new set of empty chokers.

Specifications of the three clippers and two saws are illustrated in Table 4.

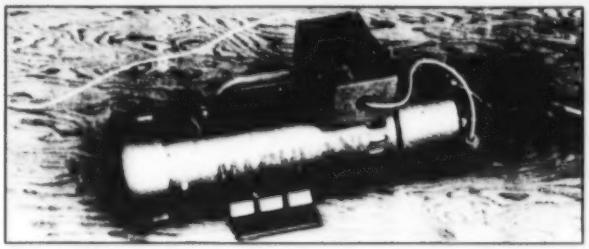

Figure 23

Advantages and Limitations

There have been few direct comparisons between the individual clipping or sawing systems. Comparisons between clipping/sawing systems and other aerial collection techniques are outlined in Table 3.

Maintenance and Upkeep

In order for any clipping or sawing system to function smoothly, the cutting blades or chain must be kept clean and sharp. Pitch buildup is a particular concern. Hydraulic fluids must be checked periodically, as well as all hoses or electrical cables. The batteries used in some systems must be recharged as required.

Aircraft

The three clipping systems and the Highland chain saw all utilize Bell 206B helicopter exclusively, primarily because of its widespread availability, relatively low cost, and large rear passenger compartment. The saw and choker system, since it does not utilize the rear passenger compartment, could conceivably use any helicopter with sufficient lifting power to carry the crew and payload.

Figure 24

Table 4. Clipper/saw machines specification and manufacturers.

Manufacturer (supplier)	Canadian Helicopters	Northern Mountain Helicopters	Frontier Helicopters	Highland Helicopters	Saw & Chokers (no specific manufacturer)
Equipment type	Electro-hydraulic clipper	Electro-hydraulic clipper	Electro-hydraulic clipper	110V electric chainsaw	12V electric chainsaw
Illustration (figure)	(Figure 19)	(Figure 20)	(Figure 21)	(Figure 22)	(Figure 24)
Electrical power source	24V hardwire (12V battery available)	24V hardwire and 12V battery pack	24V hardwire	24V-110A converter (hardwire)	12V battery
Dimensions/mass overall length -cutter head (or saw) -power pack	67cm/5kg 60 X 40 X 26 cm Plastic shipping container 25 kg	67cm/5kg 60 X 40 X 26 cm Plastic shipping containers (2) 25 + 16 kg	110cm (long model) 67cm (short model) 5kg 50 X 40 X 50 cm Fabricated housing 18 kg	55cm (20cm bar) 3.5kg 40 X 15 cm diam. housing 10 kg	50cm (20cm bar) 3.5kg Standard 12V auto battery N/A
Power pack location (in use)	Baggage compartment	Baggage compartment	Front passenger seat	Front passenger foot well	Rear passenger compartment
Replacement costs	$10,000	$10,000	$15,000	$1,500	$1,000
No. in circulation	20	4-12V; 2-24V	4	9	1 (easily made up)

Availability/Supplier/Costs

All clipper or saw systems (with the exception of the generic saw and choker system) are manufactured/supplied by helicopter firms. They are normally available to the user on an all found rate (either per hectolitre or hourly) which includes helicopter, pilot(s), operator(s), clipper or saw. Fuel is normally an additional item. For more supplier information, see Appendix 1.

Topper: Fandrich Tree Shear

Description and Dimensions

The Fandrich Tree Shear, or the Topper, is currently the only aerial tree topping device in use in B.C. The tree shear consists of a circular fiberglass cone capped with a metal shearing head (Figure 25). The cone is surrounded by an aluminum frame and nylon mesh basket which also extends out to one side of the unit. The tree shear is suspended beneath a helicopter by three wire cables, attached to the cone base and the aluminum framework. There is also a 24V electrical cable hookup to the aircraft.

Overall length of the tree shear is 3 m and it weighs approximately 167 kg. The cone itself is 2.1 m in diameter at the base and 1.2 m high. The shearing head has a maximum aperture of 0.7 m.

The heart of the Topper is the cutting arm which moves in a 90° arc across the aperture in the shearing head. The cutting arm acts to guide the tree top into a cutting slot, cut off the top, and push it into the collecting basket. Actual cutting is performed by two double-bevel tool steel blades, 15 cm in length. When fully closed, the blades overlap each other in a scissors action, but do not contact. Figure 26 shows the cutting arm 80% closed and illustrates the cutting slot, blades, and the Y-shaped pusher arm that ensures that the top falls into the basket. The cutting arm is moved by a double acting hydraulic cylinder, powered by a pump and 5 hp Honda gasoline engine that are housed on the outside of the cone body (Figure 25). A switch controlled by the pilot activates solenoid valves that open or close the cutting arm. It takes 3.5 - 4 seconds to close and slightly less to open the cutting arm.

Method of Operation

The Topper is lowered over a tree until the cone-bearing top (approx. 2.5 m) is projecting through the opening in the shearing head. The pilot then triggers the cutting head mechanism, cutting off the top of the tree. The top falls into the collecting basket (Figure 5, page 6). If desired, other cuts may be made on the same tree or another tree chosen. The tree shear has a maximum cut capacity of 15 cm. Unloading of the tree shear is done manually by lifting tops out of the basket once the rake is set down in the unloading zone.

Maintenance and Upkeep

The Topper has some complicated components that require more regular maintenance. The many hydraulic hoses and fittings should be periodically checked. The cutting arm pivot points and travel slots should be greased several times each day. Like any aerial device, the suspension cables and electrical control cables should be continually checked for fraying and loose connectors.

The Honda gasoline engine is a proven performer with a two-hour fuel capacity. It is normally refueled during hourly rest stops or while the helicopter is being refueled. The engine's crankcase oil and air cleaner should be monitored regularly. The manufacturer recommends changing the engine crankcase oil at regular intervals.

Earlier models of the Topper suffered from three major drawbacks: cutting blades bending and jamming; engine stalls; and tops falling out. The manufacturer has addressed these concerns by providing thicker blades, pressure relief valves to prevent the hydraulic cylinder from overworking, and a higher collecting basket. Recent users of the tree shear have reported that the tool performs very well with these improvements.

Figure 25

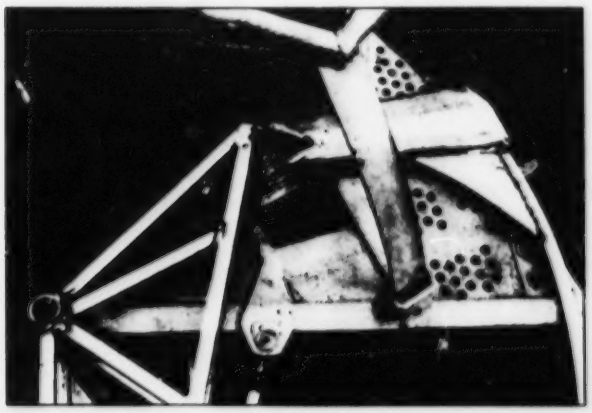

Figure 26

Aerial Cone Collection Systems

Suitable/Preferred Aircraft

Suitable: Bell 206B, Hughes 500D, Turbo Hiller
Preferred: Bell 206B or Turbo Hiller

The tree shear does not use helicopter lift to remove branches or tops. The manufacturer/supplier specifically advises against using a helicopter with a lift in excess of 682 kg to prevent separation of the support cables from the tree shear.

Transportation

The Topper may be transported on a small trailer or on a framework over a pickup box. Due to its weight, manual loading is difficult, but not impossible. Transport costs are normally the responsibility of the user.

Advantages/Limitations

Advantages	Limitations
• no helicopter lift required to remove branches	• involves complex machinery (potential down time)
• can reach down into forest canopy	• has moving parts and thus more maintenance required
• can make multiple cuts on one tree	• rental surcharge fixed, therefore no economies of scale
• does not require an operator	• engine on the Topper body may be a concern during high fire hazard conditions
• removes entire top	• arduous manual unloading of tops
	• transport costs

Manufacturer/Availability/Costs

The Topper is manufactured and supplied by Fandrich Cone Harvesters Ltd. The tree shear is rented to users (generally helicopter companies) on a seasonal or job basis. There is a flat rental fee of $440.00 plus a surcharge of $39.00 per hectolitre. The renter/user is responsible for transport costs and daily running costs as well as any extraordinary repair over and above regular wear and tear. Fandrich Cone Harvesters Ltd. also requires that the renter carry insurance for the tree shear. Replacement cost of the unit is $8000.00.

There are seven Toppers in circulation, plus another five in the construction phase. This unit is patented in Canada and the U.S.

Safety

Aerial cone collections involve activities that can be hazardous. This section will outline some general safety factors to consider. The crewing, maintenance, and operation of aircraft are governed by Transport Canada Regulations, and are the responsibility of the carrier. All other aspects of an aerial cone collection fall under the auspices of the Workers' Compensation Board of British Columbia.

Safety on an aerial collection is everyone's responsibility. The collection supervisors can ensure that safe work practices are being followed by holding daily pre-work and post-work briefings, as well as outlining potential safety hazards and ways to lessen such hazards. It is, furthermore, important to ensure that everyone fully understands his responsibilities during the collection. Each phase in an aerial collection, from in-air harvesting through unloading the collection tool, and bagging the cones has safety considerations that will be examined.

In-air Activities

The three main collection methods each have in-air safety considerations: clipping and sawing because of the helicopters proximity to the tree top(s); raking and topping because of slinging the tool and positioning it on the tree. All in-air activities are the responsibility of the pilot, who by WCB Regulation 33.14(1), shall have a minimum number of hours flying time as pilot in command. All three aerial methods are sanctioned by Transport Canada and the WCB.

Personnel fatigue must be monitored closely. The collection supervisor should suspend operation if they feel that the pilot(s) or crew(s) are too tired to work safely. Rotating pilots and crews on an hour on/hour off basis is one of the best ways to combat fatigue. Scheduled rest breaks allow the supervisor to hold the briefings mentioned earlier as well as to inspect all equipment.

Production must never receive more emphasis than safety. The possible consequences of poor safety practice far outweigh any production benefit. Anyone who sacrifices safety in favour of production should be removed from the project.

Unloading Crews

Crew unloading a collection rake or topper are working directly beneath a hovering helicopter, and thus are buffeted by rotor wash, dust, and engine noise. A minimum number of unloading crew should be used and all must be well trained. Helicopter safety training should also be part of the ground crew's training.

The following and other pertinent WCB regulations are contained in the WCB Industrial Health and Safety Regulations (Reg. Number shown in brackets).

- The ground crew must wear hardhats with chinstraps (WCB 14.12); and hearing and eye protection (WCB 33.18 and 14.21).
- The ground crew supervisor must have both radio and back-up hand signals available to communicate with the pilot (WCB 33.16).
- It is advisable that all ground crew wear brightly coloured vests, and the supervisor must wear one (WCB 33.16). The supervisor must be readily identifiable.

Users of this guide should familiarize themselves with all applicable WCB regulations.

Bagging Crews

The bagging crew(s) should be located as far as possible from the helicopter unloading area. Bagging in one area while unloading in another is an ideal situation. The helicopter must at no time fly directly over bagging crews while carrying a rake or topper (WCB 33.28).

Refueling

Supplying and delivering fuel, and refueling of the helicopter is generally the responsibility of the air carrier. The refueling site(s) should be located well away from the unloading or bagging areas. Collection supervisors should ensure that safe work practices are being followed.

First Aid

Adequate first aid supplies and equipment must be on site. Refer to WCB Industrial First Aid Regulations for details.

Fire Safety

Collection supervisors should be aware of fire equipment requirements (i.e., Forest Fire Prevention Regulation) and the local fire hazard at the time of the collection. Suitable fire fighting tools and equipment can then be arranged.

Public Safety

Aerial collections are novel enough to attract interest from the public. Collection supervisors should erect signs at all access points to inform visitors of hazards such as low flying helicopters. A collection in a well-travelled area may require a manned information post to control the movement of visitors. In addition to addressing safety concerns, such measures are good public relations.

Aircraft Management Safety

The possibility of an aircraft incident or accident, or an overdue aircraft (as might occur in a morning ferry flight) cannot be overlooked. Collection supervisors should familiarize themselves with the appropriate procedures. Ministry or other collectors can approach the Ministry Regional Air Operations personnel for further information.

Planning and Implementing an Aerial Cone Collection

An aerial cone collection, whether involving a single helicopter or several, requires careful planning and implementation to succeed. There is often a tendency to find a stand with cones and hire a helicopter to start picking. While this may give reasonable results, it may just as well end in frustration and failure if the crop turns out to be poor or even non-existent. General procedures for planning and implementing a cone collection project are well documented in *A Guide to Collecting Cones of B.C. Conifers* (Eremko, et al. 1989).

Aerial collections require extra planning, and since helicopters are expensive to operate, it is also imperative that the collection be carried out as efficiently as possible to maximize safety, quality, and production concerns.

The following discussion has been divided into four sections: Pre-collection Planning; Site; Daily Operations; and Quality Control.

Pre-collection Planning

There are often opportunities for aerial cone collections throughout the local area or within the Timber Supply Area (TSA). Collection planners should liaise with the local Forest Service District Office. Broad-based collections over a large area can benefit from economies of scale, and smaller cone quotas which might not otherwise be cost effective, may be collectable.

Potential cone crops must be monitored, especially towards the latter stages of cone development. Cone sampling should be done with increasing frequency as one nears the time of harvest. Insect attacks can happen at various points in cone development, but are often not obvious until the cones are ripe. Monitoring seed development within the cones will allow the collection planner to estimate the best time to collect. Within a large stand there is often variation in cone quality. The sampling should be intensive enough to enable the good and bad areas to be mapped out. Sampling the area on a grid basis is suggested.

It is advisable to rank each stand when several stands have a collectable crop within the same general area. The highest ranking should naturally be harvested first, but other stands, even over and above the collector's quota, should be identified in the event that higher priority stands become unsuitable at the last moment. Situations may occur where there are both time and resources left to carry out a further collection, and in this case alternate areas may be harvested. Based on the information contained in this Guide, the most appropriate collection tool should be reserved or acquired. The need for repairs or maintenance should be addressed and usage instructions acquired. This early planning stage is also the time to reserve the helicopter and organize pickers.

It may be most appropriate to hire the helicopter on an hourly basis and the pickers on a production rate. This option still allows for competitive bidding and emphasizes safety over helicopter production.

Ministry of Forests personnel are reminded that they must contact their Regional Air Operations Coordinator prior to engaging in helicopter cone collections.

Site

In addition to the target stand(s) itself, consideration must be given to the helicopter landing zone (bagging area), and the fuel dump. Vehicle access to the sites is important and may need upgrading. The helicopter unloading zone should be as close as possible to the target stand. This will minimize ferry time and maximize efficiency. The unloading area should (if possible) be lower in elevation than the target stand, so that the helicopter does not have to climb up with a full load of branches. The unloading zone should have at least two entry/egress points for the helicopter, to allow for changes in wind direction and sun angle. The area must be cleared of snags and other obstacles that might endanger the helicopter. Ground debris should also be removed. Dust free sites, such as a grassy meadow, make ideal unloading areas, but logging landings are more common. Dust control, either with water or chemicals, is suggested, although care must be taken not to overuse it and endanger stockpiled branches. Many users lay down a large tarp on which harvested branches are placed. Tarps must be anchored very securely so they can withstand rotor down wash.

Cones can be bagged on site or hauled along with the branches to town. The choice will depend on transport costs and the logistics of moving pickers. The collection planners must decide this in advance.

Consideration must also be given to the location of the helicopter fuel dumps. Fueling areas should be well away from the unloading (bagging) area. The logistics in handling fuel can be overwhelming on a large project, but a constant supply of appropriate fuel is critical to a successful collection. Fuel supply, delivery, and transport are normally left to the helicopter company.

Daily Operations

The actual details of cone collecting using a particular tool are outside the scope of this guide. Helicopter companies generally address these activities in their operations manual, and equipment manufacturers/suppliers also provide specific instructions. The users of this guide should be aware of these general techniques, while remembering that in-air activities are always left to, or under, the direction of the pilot.

A daily discussion with everyone involved in the collection is a good way to invoke a team spirit. There should be a detailed briefing with all the pilots, ground crew, supervisors, and equipment operators prior to start-up. A pre-flight check of the helicopter and the collecting tool is necessary to ensure a safe and efficient operation. The equipment check should be repeated several times during the day. Sufficient maintenance tools and supplies (such as grease and hydraulic oil) should be on hand to maintain the

collecting tool. Communication between all those involved in the collection is important, not only for safety, but for project coordination. Except in an emergency, the collection supervisor should refrain from talking to the pilot during picking to avoid distractions. A rotating duty schedule of one hour on/one hour off is recommended for both pilots and operators to avoid fatigue and maximize daily use of the helicopter and collecting tool.

It is useful to have spare picking tool parts on hand. This may include having an extra tool standing by. This is standard practice with aerial clippers, but somewhat more difficult when dealing with rakes or the Topper. An alternative may be to stay in close communication with the supplier so that a replacement unit will be available quickly.

Users have reported dropping both rakes and clipper heads on occasion either by accident or in an emergency situation. Recovery of a rake may be possible even if it was dropped over a tree. A long cable or chain equipped with a grappling hook has been used in the past to hook onto the rake's rigging and retrieve it. To prevent recovery tools from rebounding upwards into the rotor disk, they must not be made of a stretchy material like rope. A collection planner should arrange that a suitable recovery tool be either on site or quickly available. It is also advisable to discuss such a contingency with the helicopter company and agree on costing arrangements while retrieving the old rake or transporting a new one. No one has reported dropping a Topper, but the same procedures apply. Clippers that are stuck or abandoned on the tree top can possibly be cut free with another clipper.

Rakes and toppers that cannot be retrieved with a retrieving hook will have to be freed by falling the tree. Expert fallers should be used, both for safety purposes and in an attempt to salvage the collecting tool. Any collection tool that is lost and retrieved must be thoroughly examined and tested prior to its reuse.

Quality Control

After safety concerns, the quality of the cones/seeds is of utmost importance. Aerial collection is unique in that the picker and even the supervisor do not generally see the crop tree, and that very large amounts of cones and branches are stockpiled in one area prior to bagging. This places the responsibility to collect from only high quality trees almost entirely with the pilots or clipper operator. The collection supervisor can ensure that quality standards are high by choosing and delineating target stands, within the desired elevation range, with a high proportion of quality crop trees; by carefully instructing the pilot(s) in regards to the location of these stands and characteristics of quality crop trees; and by continually monitoring the loads brought in by the helicopter.

Load monitoring is particularly important for it is the only way to gauge the quality of the cones and seeds as they are delivered. Such monitoring can be performed quickly (e.g., by cone slicing), and is well worth the effort. A sudden drop in quality could signify a portion of the stand with less than ideal crop trees – and should be avoided. An intensive pre-collection reconnaissance mapping the stand on a grid basis will have already identified poorer sections of the stand. Monitoring each load as it comes in is also the best way to determine one's position in that crop's collection window. At some point, the number of open cones being collected will be high enough to stop the collection.

Since the choice of crop trees is left largely to the pilot and/or operator, it is important to utilize those with the most experience. This, of course, is not always possible. Helicopter companies generally try to supply their most experienced people. Aerial cone collections require a degree of skill that cannot be gained from other work.

Aerial cone collections deliver a very large number of cones and branches to a central point for stockpiling prior to bagging. These branches require special handling to ensure that the cones do not overheat or become mouldy. Cones should be bagged and transported to interim storage as quickly as possible. High moisture content cones such as *Abies*, cedars, and western hemlock may need to be half-sacked to encourage drying.

Cones that were collected first should be bagged first to minimize their time on site. When weather conditions dictate, piles of branches may need to be periodically loosened up and turned in order to dissipate heat and lessen the growth of mould. Long-handled hay forks are ideal for this purpose.

There are inevitably many cones that fall off the branches and accumulate on the unloading zone. These cones should be collected unless they are open or very dirty. Tarping the unloading zone aids in recovering these individual cones.

Also, proper post-collection care and handling of cones must not be ignored.

Contact Persons

The following is a listing of individuals who have had experience with a particular species. The persons noted in this section are not the only ones with knowledge in aerial cone collections. In fact, the experience base is so large that it would be necessary to list everyone who has ever collected cones. The persons who are mentioned, however, will be able to supply other contacts to users who are interested in pursuing a particular subject further.

Amabilis and Grand fir

Contacts:

Ed McDonald, McDonald Seed/Seedling Services, Nanaimo
Bill Dumont, Western Forest Products, Port McNeill
Larry Sigurdson, B.C. Ministry of Forests, Vancouver Forest Region, Burnaby
Don Piggot, Yellow Point Propagation, Ladysmith
Hugh Bomford, Canfor, Englewood Div., Woss Camp

Subalpine fir

Contacts:

Doug Davies, K.D.M. Forest Services, Terrace
Peter Poland, Ministry of Forests, Clearwater Forest District, Clearwater
Jill Dunbar, Ministry of Forests, Prince Rupert Forest Region, Smithers
John Revel, Ministry of Forests, Prince George Forest Region, Prince George

Douglas-fir (coastal)

Contacts:

Ed McDonald, McDonald Seed/Seedling Services, Nanaimo
Don Piggot, Yellow Point Propagation, Ladysmith
Norm Caldicott, N&R Forest Management, Squamish
Larry Sigurdson, Ministry of Forests, Vancouver Forest Region, Burnaby

Douglas-fir (interior)

Contacts:

Paul Sears, Rustad Bros., Prince George
John Casteel, Lakeland Mills, Prince George
Al Waters, West Fraser, Quesnel
Don Purdy, Ministry of Forests, Vernon Forest District, Vernon
John Revel, Ministry of Forests, Prince George Forest Region, Prince George
Terry Carter, Ministry of Forests, Prince George Tree Improvement Station, Prince George
Hans Lussenburg, Ministry of Forests, Red Rock Research Station, Prince George

Western redcedar

Contacts:

Bill Dumont, Western Forests Products, Port McNeill
Ron Elder, Fletcher Challenge, Crofton
Ed McDonald, McDonald Seed/Seedling Services, Nanaimo

Yellow-cedar

Contacts:

Ed McDonald, McDonald Seed/Seedling Services, Nanaimo
Ron Elder, Fletcher Challenge, Crofton
Bill Dumont, Western Forest Products, Port McNeill

Western hemlock

Contacts:

Larry Sigurdson, Ministry of Forests, Vancouver Forest Region, Burnaby
Norm Caldicott, N & R Forest Management, Squamish
Ron Elder, Fletcher Challenge, Crofton

Western white pine

Contacts:

Susan Harris, Westar Timber, Nakusp
Bill Beard, Ministry of Forests, Revelstoke Forest District, Revelstoke
Gord Grunerud, Ministry of Forests, Nelson Forest District, Nelson
Denis Beinder, Ministry of Forests, Nelson Forest Region, Nelson

Lodgepole pine

Contacts:

Lynn Norton, Singletree Ventures Ltd. Hazelton
Paul Sears, Rustad Bros., Prince George
Don Couch, Riverside Forest Products, Lumby
Doug Witala, West Fraser, Smithers
Susan Harris, Westar Timber, Nakusp
Warren Mitchell, Ministry of Forests, Victoria
Randy Trerise, Pope and Talbot, Midway

Spruce (coastal)

Contacts:

Don Piggot, Yellow Point Propagation, Ladysmith
Norm Caldicott, N & R Forest Management, Squamish
Greg Templeman, Fletcher Challenge, Boston Bar
Larry Sigurdson, Ministry of Forests, Vancouver Forest Region, Burnaby
Mike Whitehouse, Ministry of Forests, Sechelt Field Office, Sechelt

Contact Persons

Spruce (interior)

Contacts:

Mark Clark, Northwood, Prince George
Paul Sears, Rustad Bros., Prince George
John Casteel, Lakeland Mills, Prince George
Lynn Norton, Singletree Ventures Ltd., Hazelton
Bob Gray, Ministry of Forests, Vernon Forest District, Vernon
Claire Hewson, Ministry of Forests, Kalamalka Research Station & Seed Orchard, Vernon

Further Information

Listed here are further individuals who have a general knowledge of aerial cone collection equipment and of other knowledgeable people.

Ingrid Hedin, FERIC, Vancouver
Dave Wallinger, Ministry of Forests (Retired) Victoria
Cam Bartram and Paul Birzins, Ministry of Forests, Silviculture Branch, Victoria

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Appendix 1 – Suppliers of Aerial Cone Collection Equipment[a]

Company Name (Head Office)	Contact Person/ Phone	Equipment	Page
Canadian Helicopters Ltd. 4391 Agar Drive Richmond, B.C. V7B 1A5	Barry Horn (604) 278-5502	Clipper	15
D.K. Helicropper International Ltd. 3750 Nanaimo Crescent Abbotsford, B.C. V2S 6W8	Gene Drader (604) 852-2715	Modified Chilson rake	10
Fandrich Cone Harvesters Ltd. 2461 Sunnyside Place Abbotsford, B.C. V2T 4C4	Dr. Helmut Fandrich (604) 850-0666	Fandrich rake Fandrich topper	11 17
Frontier Helicopters Ltd. Box 220 Abbotsford, B.C. V2S 4N9	Rod Brownless (604) 853-5887	Clipper	15
Highland Helicopters Ltd. 4240 Agar Drive Richmond, B.C. V7B 1A3	Don Browder (604) 273-6161	Saw	15
Northern Mountain Helicopters Ltd. Box 368 Prince George, B.C. V2L 4S2	Denis Ford (604) 963-9622	Clipper Chilson rake	15 10
Robe Innovations Inc. 1690 Stanhope Place Victoria, B.C. V0P 1Y1	Dr. Dan Bergerud (604) 595-7868	Bicone rake	13

[a] Please notify Silviculture Branch, Extension Services – Seed of any revisions.

Appendix 2 – Experienced Suppliers of an Aerial Cone Collection Service – Helicopter Companies[a]

Company
Contact (Head Office)
Telephone No.

Campbell Helicopters Ltd.
Box 2008
Clearbrook, B.C.
V2T 3T8
Laura Siemans
(604) 852-1122

Canadian Helicopters Ltd.
4391 Agar Drive
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V7B 1A5
Barry Horn
(604) 278-5502

Capital Helicopters Ltd.
4193 - 104 Street
Delta, B.C.
V4K 3N3
Norm Rafuse
(604) 596-2423

Crowsnest Helicopters Ltd.
Box 928
Fernie, B.C.
V0B 1M0
Ted Mould
(604) 423-7611

D.K. Helicropper International Ltd.
3750 Nanaimo Crescent
Abbotsford, B.C.
V2S 6W8
Gene Drader
(604) 852-2715

Estlin Helicopters Ltd.
Box 445
Chetwynd, B.C.
V0C 1J0
Lorne Dalke
(604) 788-3771

Frontier Helicopters, Ltd.
Box 220
Abbotsford, B.C.
V2S 4N9
Rod Brownless
(604) 853-5887

Company
Contact (Head Office)
Telephone No.

Highland Helicopters Ltd.
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V7B 1A3
Don Browder
(604) 273-6161

Long Beach Helicopters Ltd.
2363 Cienar Drive
Nanaimo, B.C.
V9T 3L6
Peter Oehlenschlager
(604) 758-0024

Michael Air Helicopters Ltd.
Site 11, C 13, RR #2
Kelowna, B.C.
V1Y 7R1
Mike Poole
(604) 765-3611

Northern Mountain Helicopters Ltd.
Box 368
Prince George, B.C.
V2L 4S2
Denis Ford
(604) 963-9622

Pemberton Helicopters Ltd.
Box 579
Pemberton, B.C.
V0N 2L0
John Goats
(604) 894-6919

Prism Helicopters Ltd.
12 - 11465 Baynes Road N.
Pitt Meadows, B.C.
V3Y 2B3
Dave Zall
(604) 465-7979

Riverside Helicopters Ltd.
1116 Herring Gull Place
Parksville, B.C.
V9P 1R2
Paul Gibbons
(604) 248-4225

[a] Additional services (i.e., crop reconnaissance, crop monitoring, ground crews) may be offered in-house or by subcontract. Please notify Silviculture Branch, Extension Services – Seed, of any revisions.

Appendix 2 – Experienced Suppliers of an Aerial Cone Collection Service – Helicopter Companies[a]

Company Contact (Head Office) Telephone No.	Company Contact (Head Office) Telephone No.
Tundra Helicopters Ltd. 5333 - 216th Street Langley, B.C. V3A 4R1 Steve Wilson (604) 534-6535	Vancouver Island Helicopters Ltd. #1 - 9600 Canora Road Sidney, B.C. V8L 4R1 Ken Norry (604) 656-3987
Valley Helicopters Ltd. 62700 Airport Road Hope, B.C. V0X 1L0 Fred Fandrich (604) 869-2131	Yellowhead Helicopters Ltd. Box 190 Valemount, B.C. V0E 2Z0 Garry Forman (604) 566-4401

Appendix 3 – Experienced Suppliers of an Aerial Cone Collection Service: Consultants[a]

Company
Contact/Telephone No.

Ed McDonald
1901 Bay Street
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V9T 3A6
Ed McDonald
(604) 758-5379

K.D.M. Forestry Services
300 - 4722 Lakelse Avenue
Terrace, B.C.
V8G 1R6
Doug Davies
(604) 635-9540

Ken Cutt
Cedar Hill Road
RR #1
Falkland, B.C.
V0E 1N0
Ken Cutt
(604) 379-2431

McCleod & Baines Associates Ltd.
101 - 2666 Queensway
Prince George, B.C.
V2L 1N2
Angus McCleod/Kim Baines
(604) 562-1828

Mountain View Silviculture Ltd.
Box 3849
Smithers, B.C.
V0J 2N0
Mark Adamson
(604) 847-4822

N & R Forest Management
Box 5118
Squamish, B.C.
V0N 3G0
Norm Caldicott
(604) 892-1026

Quality Seed Collections Ltd.
Box 1531
Kamloops, B.C.
V2C 4M9
Doug Gregory
(604) 374-9689

Company
Contact/Telephone No.

R.J.A. Forestry Ltd.
Box 2528
1175 Main St.
Smithers, B. C.
V0J 2N0
Bill Camenzind
(604) 847-3225

Roy Scully
1885 Queensway Avenue
Terrace, B.C.
V8G 3X1
Roy Scully
(604) 635-4685

Singletree Ventures Ltd.
Box 514
Hazelton, B.C.
V0J 1Y0
Lynn Norton
(604) 842-6266

Tawa Enterprises Ltd.
1415 Sante Fe Avenue
Prince George, B.C.
V2N 2K5
Carl Loland
(604) 561-1141

Yellow Point Propagation
RR #3, Long Lake Road
Ladysmith, B.C.
V0R 2E0
Don Pigott
(604) 245-4635

[a] Additional services (i.e., crop reconnaissance, crop monitoring, ground crews) may be offered in-house or by subcontract. Please notify Silviculture Branch, Extension Services - Seed, of any revisions.